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16. ABSTRACT

During the past decade it has become increasingly evident that a change is needed to expedite quality control procedures of highway construction so as to maintain the pace of the industry.

One of the obvious ways to accomplish this is to require the contractor to be responsible for quality control, with the owner only assuring himself of the quality of the product. There is nothing new in this idea in that it has been done in Europe for years. In Europe, however, quality assurance is achieved by long term guarantees and making the contractor responsible for maintenance. This procedure seems unacceptable in America, so we must devise other methods. The simplest way would be to utilize significant end point specifications. Unfortunately, everything does not lend itself to an end point test. What do you do with a rejected bridge, for instance?

Thus it is clear that the most important step in implementing control by the contractor is the development of a significant quality assurance program. There are of course several steps required to develop an effective program. In general chronological order they are 1) policy determination 2) program plan 3) development of significant control test procedures and a means of measuring the significance 4) development of an assurance control system, 5) education of engineering and contractual personnel, and 6) preparation of specifications and procedures and their introduction into contracts.

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STEPS TOWARD IMPLEMENTING CONTROL BY THE CONTRACTOR

by John L. Beaton *

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(3) development of significant control test procedures and a means of measuring the significance (4) development of an assurance control system, (5) education of engineering and contractural personnel, and (6) preparation of specifications and procedures and their introduction into contracts.

Actually the first two steps and the last are the only ones in pure sequence. The rest are intermingled, especially that of education. This may be accomplished by involving the control engineering personnel and the industry in the complete research program as well as conducting formal courses. The first step or policy decision can be made either to definitely work towards the end of quality control by the contractor or as we have done in California to move in that direction as a definite goal but defer the final decision until we can evaluate all factors, such as contractors' attitudes and action towards implementation. Incidentally, it was decided that all quality characteristics of a project could be involved including geometric, physical, chemical and mechanical properties and characteristics.

During our analysis of the factors involved in quality control by the contractor, the following advantages were brought out.

1. Testing and inspection is a necessary cost, and the money can be more efficiently managed by the one who directly controls production.

2. The contractor is the only one who is in position to anticipate and order the necessary adjustments in production to

assure proper quality.

3. Quality is built into a product - not inspected into it. The best that an owner can do is to conduct an effective quality assurance program. Testing, inspection, evaluation, and appropriate action by the contractor or producer is a means of building quality into the product.

4. If the contractor or producer does his own testing, he is forced to know his product better, which in itself could result in an improved product, perhaps at a reduced cost.

5. Statistical specifications can be used more efficiently if integrated into the contractor's or producer's effort. The contractor or producer by maintaining a quality control chart mounted or displayed so that everyone can see and evaluate the degree of control will encourage and simplify quality control as well as establish an easy means of communication concerning his quality control.

6. The State contracts directly with a general contractor. The contractor may purchase from a supplier and do his own hauling, spreading and compaction, or some other combination of items. Controversies can arise as to responsibility when material handled by more than one organization does not meet the specifications. With the contractor responsible for quality control, the State no longer would need to arbitrate such controversies.

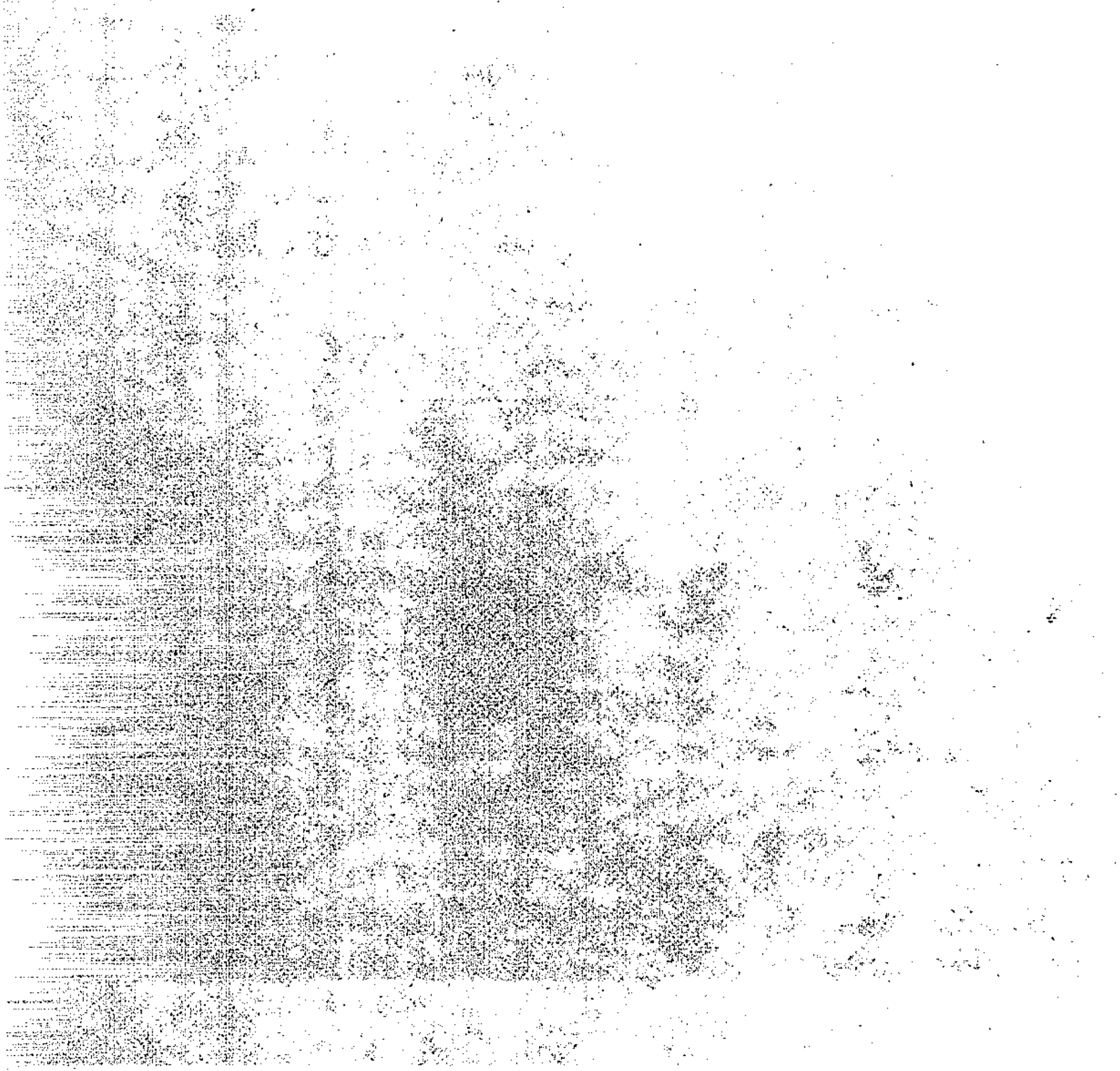
7. The owner's inspecting and testing forces would have more time to devote to broader construction problems, which should insure a better overall project.

The following disadvantages were considered.

1. Small contractors may not have the necessary facilities to do their own quality control. This will necessitate the hiring of an outside agency. In remote areas this may be a problem and add to the cost of the project.
2. From the user's viewpoint, quality control by the contractor would seem more effective when an endpoint specification is available. Not all products have adequate endpoint specifications.
3. Satisfactory quality control by the contractor will only be achieved if it is handled by personnel trained in quality assurance procedures with sufficient authority to actually control the quality of the contractor's product. There is a shortage of such experienced people.

Insofar as developing a program is concerned, we originally felt that there were two directions that could be taken. An existing system could be used and merely written into the specifications that henceforth the contractor would be responsible for such work; or we could investigate the reliability of several control procedures with our own forces and after they were proven, adopt the best as the responsibility of the contractor. Historically, California has had the control of quality directly in the hands of the Resident Engineer. For this reason we chose the latter course.

Two systems of quality control by the manufacturer are currently under trial. First, for products purchased directly by the contractor from manufacturers, we use either a certification



system or a lot system. In the latter, random samples are selected from a lot and tested. The lot is either accepted or rejected based on these tests. The certification system is based on acceptance of an industry's control procedure followed by an audit assurance program.

Acceptance of products manufactured by the contractor on the job, such as aggregates, is based on a process control method using a running average, based on five tests, plotted on control charts. We regard this method as having good potential for use by the contractors. It seems to work well for relatively uniform materials put together by a continuous process. So far it does not seem to be applicable to heterogenous materials placed in a discontinuous manner, such as a roadway embankment where the contractor has no control of the quality of the material - only the geometry and the amount of compaction required. We therefore identify a layer of such a fill as a lot. Random tests are made and the entire lot accepted or rejected.

As a part of this program a study to determine the significance and reliability of our various test procedures was initiated. This part of the program is now well under way, and we have arrived at the step of introducing statistically based specifications into our contracts. The education of our engineers and contractors is threaded into our studies in that the resident engineers and their staffs were involved in the development of the statistical procedures, and now the contractors are becoming involved, even though the quality control is still our responsibility.

These specifications provide statistically for the variations that were found by research studies to exist in acceptable materials. Many of these new specifications are included in the 1971 California Division of Highways Standard Specifications.

Specifications similar to ours are being used nationwide by public and technical agencies who have recently adopted the statistical specification concept. For instance, the American Concrete Institute's specifications now reflect the statistical concept when specifying concrete strength. The manufacturing industry has used this concept for at least 20 years while those of us involved in the heavy construction industry have just recently begun to recognize its potential value. The use of statistical type specifications is an important step toward accomplishing quality control by the contractor or producer. Such specifications must be developed, as we have done, to take into account limitations in technology and variations in sampling and testing procedures compatible with heavy construction.

Obviously, our next step is trial projects specifying quality control by the contractor. This will require the contractor to adopt a quality control plan. The quality control plan from the contractor should tell and explain who, when, how, and where. It should state who will do the inspection and testing (the contractor's organization or a private testing agency), when the testing and inspection will be done, how samples will be selected for testing and inspection, and where the work will be done. This plan would be submitted to the specifying agency for evaluation by a quality

assurance unit set up to evaluate and approve such plans. The quality assurance unit should be highly qualified in the required technology and must be able to mesh their program with the contractor's so that the specified level of quality can be verified. Some form of laboratory certification will ultimately be required.

The final step in the process is, of course, adoption as a standard. We are still exploring the best possible approach to the contractual requirements for testing and inspection which are to be placed on the contractor. Several questions are under consideration. Should we specify the system, or should we allow the contractor to develop his own quality control system requiring only approval of the State? Should we adopt a complete set of penalty requirements which might allow the incorporation of borderline or substandard materials in the structure, or should we remain with our "go"-"no go" requirements? Obviously there are some requirements which could be handled by penalty and other more critical requirements that must meet minimum requirements. We have not yet worked out this system, but it is our next step forward in the process of placing quality control in the hands of the contractor.

As I indicated in my introduction, the true key to this full process is the approach to acceptance testing that will be finally adopted. We are a long way from a sophisticated

quality assurance program, simply because we have not yet developed significant end point tests in all areas, nor is it clear that we can. I think, however, that this must be recognized and worked into the system probably by developing measurements of control procedures and acceptance of some items on a lot basis.